Journal of Ideas in Health
e ISSN: 2645-9248 Journal homepage: www.jidhealth.com Open Access

Original Article

Predictive factors of successful extracorporeal shockwave lithotripsy (ESWL) for renal stones: evidence of retrospective study

Shukur Mahmood Yaseen[1], Saad Ahmed Ali Jadoo[2*], Ayad Aziz Abdullah[3], Anmar Shukur Mahmood[4], Wassan Nasrat Abd Al-wahaab[1]

Abstract

Background: Extracorporeal shockwave lithotripsy (ESWL) has proved to be effective in treating ureterolithiasis. This study aimed to investigate the predictive factors related to success ESWL among patient presented with renal stone.

Methods: A retrospective study was conducted among 40 patients who underwent ESWL at the urology department, Baquba Teaching Hospital, Diyala University, Iraq. Data was collected between 1st October 2018 and 31st January 2019 for renal stones diagnosed by non-enhanced spiral computed tomography (NCCT). The success rate defined as no stone or the remnant stones < 4 mm. We analyzed predictive factors by using multiple linear regression.

Results: The success rates ranged from 50-90%. In the univariate analysis, body mass index (BMI), skin-to-stone distance (SSD) and the renal stone-attenuation value (in Hounsfield units, HU) were found to be significantly correlated with the outcome of ESWL ($p<0.05$). However, in the multiple linear regression, only the HU ($B = -0.619$, $P < 0.0001$; 95% confidence interval [CI]: 0.03 to 0.07) was the independent predictive factor.

Conclusion: Hounsfield Unit is an independent predictive factor influencing the success of ESWL for treating renal stones.

Keywords: ESWL, Renal stone, NCCT, Hounsfield Unit, Baquba, Diyala, Iraq

Background

Some facts and figures cannot overcome when discussing the issue of renal calculi and ureteral calculi (ureterolithiasis). First, the incidence rate is increasing at the global level regardless of region, race, gender, and age [1]. Second, diagnosis often delayed when the stone is large enough to affect the function of the urinary tract system [2]. Third, the significant change in lifestyle and bad dietary habits have emerged as other complicating factors in the way of treatment [3]. Fourth, the lack of awareness about the causes and the risk of urinary tract stones among most people [4]. Fifth, there is a misconception that when removing stone by any way of treatment means full recovery. Unfortunately, the recurrence rate is high [5]. Sixth, the magnitude of ureterolithiasis goes beyond the health and psychological impact on serious economic and social repercussions [6]. Seventh, the technological advances in diagnosis and treatment of ureterolithiasis, especially the introduction of non-contrast computed tomography (NCCT) and extracorporeal shockwave lithotripsy (ESWL) in the early 1980s, increased the chances of early diagnosis and the safe treatment with fewer side effects [7].

Eighths, NCCT is superior to Intravenous Urogram (IVU) in the sensitivity and specificity regarding the diagnosis of the renal and ureteral calculi. However, NCCT's safety is not guaranteed due to the high radiation dose [8]. Ninth, the success and failure rate of ESWL have been extensively discussed in previous research and most of them revolved around the age of patient, gender, body mass index (BMI), stone size, location, the skin-to-stone distance (SSD), the renal stone-attenuation value (in Hounsfield units, HU), and presence or absence of complications and so on. In this current study, we are also trying to find out the most important predicting factors for the success of the ESWL procedure among sample of Iraqi patients presented with renal stone.

*Correspondence: drsaadalezzi@gmail.com
Department of Public Health, Faculty of Medicine, Bezmialem Vakif University, Istanbul, Turkey
Full list of author information is available at the end of the article

Methods

A retrospective analysis was performed among 40 patients who underwent ESWL between 1st October 2018 and 31st January 2019 for renal stones at the urological department of Baquba Teaching Hospital. A non-enhanced spiral computed tomography (NESCT) was used to diagnose the included cases.

Table 1 Inclusion and exclusion criteria

No.	The Main Criteria	Inclusion & Exclusion
1.	Stone size ≥4 mm	+
2.	Solitary stones	+
3.	Radiopaque stones on the pretreatment plain radiography	+
4.	Stone < 20mm	+
5.	Ongoing urinary tract infections	-
6.	Blood coagulation disorders	-
7.	Ureteral Stricture	-
8.	Neurogenic bladder	-
9.	Polycystic kidney	-
10.	Multiple stones	-
11.	Obstructed stones with severe grades of hydronephrosis	-
12.	Renal failure	-
13.	Pregnancy	-

(+) Inclusion criteria, (-) Exclusion criteria

Patient age, gender, body mass index (BMI), stone size, location, skin-to-stone distance (SSD), Hounsfield unit (HU) were the main variables recruited to predict the successful procedure of ESWL (Table 2).

For each patient, height in meters and weight in kilogram were measured to calculate the BMI following the formula: "BMI = kg/m2 where kg is a patient's weight in kilograms and m2 is their height in meters squared". An average of three different measures (0°, 45°, and 90°) from the skin to renal stone has been taken on NESCT to determine the SSD for each stone. The stone attenuation values (Hounsfield units [HU]) were measured following the steps described by Choi et al. [9]. The first step was to obtain images using the Non-enhanced helical technique by considering the 5-mm collimation breadth from the tip of the kidneys to the level of the pubic symphysis. The second step was to analyze the stones in largest dimension, where three regions of interest (ROI) with similar-size ROI (2.0±0.5 mm2) were considered. In the third step, the average measure of three ROIs was considered as the HU for that stone.

All patients were planned for second NCCT 30 days after the ESWL to assess the success rate and to check for the possible complications. In this study, the success rate of ESWL was considered when the targeted stone disappeared completely (stone free) or with remaining of residual stone fragments of less than 4 mm size as clinically insignificant remaining fragments (CIRF). However, residuals fragments of ≥4 mm considered the sign for the failure of ESWL.

ESWL procedure performed under pethidine sedation and the supervision of a urologist by using an electroconductive lithotriptor (Sonolith Praktis, EDAP TMS, Vaulx-en-Velin, France). The stones fragmented under fluoroscopic guidance. When there was a large fragment with a long diameter >4 mm, ESWL was tried repeatedly until each fragment became smaller than 4 mm. The failure of ESWL was defined as remnant stones larger than 4 mm at three months after the first session.

Statistical analysis

Descriptive data presented as the mean (SD). Univariate analysis was used to assess the association between the various factors and outcomes. An independent sample t-test was used to compare means between the categorical variable, e.g., gender and stone location with Stone Free Rate. Pearson correlation coefficient was used to test the relation between the continuous variables, e.g., age, BMI, stone size, skin to stone distance and the values of the Hounsfield unit and the outcome Stone Free Rate. After that, the significantly associated variables were tested with multiple linear regression analysis to identify the independent predictors of successful treatment. Statistical analysis performed by using SPSS ver. 16.0 (SPSS Inc., Chicago, IL, USA). Values of $p<0.05$ were considered statistically significant.

Results

Descriptive analyses (univariate analysis)

Table 1 presents the descriptive characteristics of the socio-demographic variables. The patient means age (±SD) was 44.36 years (±1.80) (range, 11 to 78 years). More than half of respondent (23, 57.5%) were females and an average BMI 25.23(±3.42). Most of the patients presented with left side (22, 55.0%) renal stone with a mean stone size of 11.48 (±2.23) and average skin-to-stone distance of 80.23(±1.76) mm. The density of stones was in average Hounsfield unit of 7.1(±1.44) and average Stone Free Rate of 65.75(±11.74).

An independent sample t-test was used to compare the mean of stone free rate scores across demographic and other variables. There were no significant differences between the gender, stone location and the Stone Free Rate (Table 3).

Table 4 presents the results of the Pearson correlation coefficient with stone free rate. Two variables; SSD, and the HU found to be correlated significantly with stone free rate.

Multivariate analysis

Predictors of fragmentation

Table 5 shows the results of multiple linear regression analysis to identify the associated variables with the stone-free rate. In backward elimination (or backward deletion) the multivariate linear regression analysis (after excluding of non-contributing variables) was statistically significant, and overall, explained 38.3% of the variance in the stone-free rate, $F(38, 23.591) = 2059.753$, $P < 0.0005$. The "Hounsfield unit" appeared to be the only factors predicting the stone-free rate (Table 5). The high numbers of Hounsfield unit were more likely to have a low stone-free rate ($B = -0.619$, $P < 0.001$).

Table 2 Descriptive statistic of socio-demographic and other variables (n=40)

No.	Variables	Category	Mean (±SD)	Range	N%
1	Age	-	44.36 (SD 1.80)	(11-78)	-
2	Gender	Male	-	-	17 (42.5)
		Female	-	-	23 (57.5)
3	Body Mass Index (BMI)	-	25.23 (SD 3.42)	(16.96-34.96)	
4	Stone Location	Right side	-	-	18 (45.0)
		Left side	-	-	22 (55.0)
5	Stone Size	-	11.48(SD 2.23)	(7-20)	-
6	Skin- to- Stone Distance (SSD)	-	80.23 (SD1.76)	(50-124)	-
7	Hounsfield Unit (HU)	-	7.1 (SD1.44)	(500-990)	-
8	Stone Free Rate	-	65.75 (SD 11.74)	(50-90)	-

Table 3 An-independent sample t-test on stone free rate (n=40)

No.	Variables	Category	N%	Mean $\pm$ SD	t-test	P-value	95% Upper-Lower
1	Gender	Male	17 (42.5)	62.9 (10.5)	1.347	0.186	2.5-12.2
		Female	23 (57.5)	67.8 (12.4)			
2	Stone Site	Right	18 (45.0)	65.6 (12.9)	0.092	0.927	7.5-8.2
		Left	22 (55.0)	65.9 (11.0)			

Table 4 Pearson correlation coefficient on stone free rate (n=40)

No.	Variables	R value	Sig (2-tailed)
1	Age (years)	0.126	0.437
2	Body Mass Index (BMI)	0.251	0.118
3	Stone size (mm)	0.107	0.511
4	Skin-to-stone distance (mm)	0.402*	0.010
5	Hounsfield Unit (HU)	0.619*	0.000

Table 5 Results of multiple linear regression on stone free rate (n=40)

Variables	B	S.E.	Beta	t-test	Sig.	95% CI Lower-Upper	Tolerance	VIF
Constant	101.563	7.520	-	13.506	0.000	86.3-116.8	-	-
Hounsfield Unit	-0.050	0.010	-0.619	-4.875	0.000	0.03-0.07	0.662	1.511

Discussion

There is an agreement among urologists that ESWL contributed significantly to reducing the patient suffering and accelerating the treatment. High success rates of ESWL reported around the world associated with promising outcomes in terms of low cost, less length of patient stay (LOS) and minimal side effects [10]. In the current study, the success rate of ESWL was on average of 65.75 (SD 11.74) which in line to findings reported by Assimos et al [11]. In this study, a high correlation (r =0.619) between the HU and SFR and in multiple linear regression only HU ($p<0.001$) was significantly predicting the rate of SF.

Similarly, Berber-Deseusa et al [12] found that there was a statistically significant relationship between the HU and the success of ESWL (p = 0.01) (OR 6; 95% CI: 1.4-26.2). Massoud et al [7] concluded that the failure rate of ESWL would be more than half when treating the patients presented with the stone of 1000 HU or more. The author argued that in such case ESWL should not be considered as a first line in the treatment. In our sample, the renal stone-attenuation value was within the acceptable range of (500 to 990) for ESWL procedure [7]. Part of our study analysis showed weak correlation (r =0.308) between the weight of patients and SFR. Many studies discussed obesity and its relationship to the success of the ESWL procedure; the higher the obesity, the lower the success rate [13,14]. Obesity is associated with increased absorption of radiation and difficulty in locating the calculi [13]. Pareek et al [15] found that both BMI and HU are independent predictors for successful SEWL. However, in respect to our findings, Dede et al [13], Bulent et al [14] and Pompeo et al [16] reported in different studies that BMI does not affect SFR. Moreover, Bulent et al [14] and Pareek et al [15] found a significant relationship between the SSD and the success of ESWL.

Similarly, in our study, moderate correlation (r=0.402) was reported between the SSD and SFR. However, Jacobs et al [17] found that SSD did not have a statistically significant effect on the success of ESWL treatment. Although the results of our study found that the size of stone has no relation to the success of the ESWL procedure, however this finding conflict with previous results confirmed that the size of renal stone has a direct impact on the SFR [9,18]. Whenever the size of the stone was larger the possibility of ESWL failure is high. Joshi et al

[19] concluded that for the stone size of less than 15 mm the likelihood of SFR is high. Location of stone within the different parts of the kidney may alter the skin to stone distance especially when associated with high. Two studies carried out in Egypt [7], and Oman [20] indicated that the success rate of ESWL decreased significantly when the stone location was in lower calyceal. Dede et al [13] reported that the position of stone (right or lift kidney) was not related to the rate of SF which is in line to our findings. Concerning the sociodemographic factors, age appeared to have no impact on the outcome of ESWL. Similar results were reported in Oman [20]. Previous studies conducted by Lee et al [21] found that there were no significant differences between men and women patients concerning the success of ESWL, which is in line with our current findings. However, Shinde et al [20] found a significant gender difference, and the success rate was higher among men. The author also found that women patients were less tolerated for treatment than men [20]. The retrospective design and the inclusion of a small number of patients (only the successfully treated cases) led to a selection bias as the main limitation for this research.

Conclusion

In conclusion, the results of this study added another event that the renal stone-attenuation value (in Hounsfield units, HU) is the most potent predictor for successful ESWL. Moreover, there is a significant, but in reverse, the relationship between the value of HU and the stone-free rate.

Abbreviations

ESWL: Extracorporeal Shockwave Lithotripsy NCCT: Non-Enhanced Spiral Computed Tomography BMI: Body Mass Index SSD: Skin-To-Stone Distance HU: Hounsfield Units IVU: Intravenous Urogram
SD: Standard Deviation ROI: Regions of Interest CIRF: Clinically Insignificant Remaining Fragments SFR: Stone Free Rate LOS: Length of Stay

Declarations

Acknowledgement

We render our special thanks to all patients for their patience and help during the study. Special thanks to all directors of Baquba Teaching Hospital including the doctors and paramedical staff at the department of Urology for their unlimited support and full cooperation during the data collection.

Funding

The author (s) received no financial support for the research, authorship, and/or publication of this article.

Availability of data and materials

Data will be available by emailing drsaadalezzi@gmail.com

Authors' contributions

SAAJ is the principal investigator of the study who designed the study and coordinated all aspects of the research including all steps of the manuscript preparation. He is responsible for the study concept, design, writing, reviewing, editing and approving the manuscript in its final form. SMY, AA, ASM, and LA contributed in the study design, analysis and interpretation of data, drafting the work, writing the manuscript and reviewed and approved the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

We conducted the research following the Declaration of Helsinki, and the protocol was approved by the Ethic Committee of Faculty of Medicine, University of Diyala, Iraq (Ref: 1714 at 24-June-2018). Moreover, written informed consent was obtained from each included patient who were willing to participate after explanation of the study objectives and guarantee of secrecy.

Consent for publication

Not applicable

Competing interest

The authors declare that they have no competing interests.

Author details

[1]Department of Anatomy, Molecular Genetics, Faculty of Medicine, University of Diyala, Diyala, Iraq. [2]Department of Public Health, Faculty of Medicine, Bezmialem Vakif University, Istanbul, Turkey.[3]Department of Urology, Baquba Teaching Hospital, Diyala, Iraq. [4]Faculty of Computer Engineering, Altinbas University, Istanbul, Turkey

Article Info

Received: 24 March 2019
Accepted: 23 April 2019
Published: 17 May 2019

References

1. Pawar AS, Thongprayoon C, Cheungpasitporn W, Sakhuja A, Mao MA, Erickson SB. Incidence and characteristics of kidney stones in patients with horseshoe kidney: A systematic review and meta-analysis. Urol. Ann.2018; 10(1):87-93. http://dx.doi.org/10.4103/UA.UA_76_17.
2. Türk C, Knoll T, Petrik A, Sarica K, Seitz C, Straub M. EAU Guidelines on Urolithiasis. Uroweb 2012. Available from: http://www.uroweb.org/gls/pdf/20_Urolithiasis_LR%20March%2013%202012.pdf. [Accessed 22 Mart 2019].
3. Dai M, Zhao A, Liu A, You L, Wang P: Dietary factors and risk of kidney stone: a case-control study in southern China. J Ren Nutr 2013;23: e21-e28. http://dx.doi.org/10.1053/j.jrn.2012.04.003.
4. Alghamdi SY, Alamri AM, Alzahrani RA, Alghamdi AH, Alghamdi AA, Alghamdi AA, et al. Awareness about symptoms and role of diet in renal stones among the general population of Albaha city. The Egyptian Journal of Hospital Medicine 2018;70: 50-59. http://dx.doi.org/10.12816/0042983.
5. D'Costa MR, Pais VM, Rule AD. Leave no stone unturned: defining recurrence in kidney stone formers. Curr Opin Nephrol Hypertens 2019; 28:148-153. http://dx.doi.org/10.1097/MNH.0000000000000478.
6. Hyams ES, Matlaga BR. Economic impact of urinary stones. Transl. Androl Urol. 2014; 3:278–283. http://dx.doi.org/10.3978/j.issn.2223-4683.2014.07.02.
7. Massoud AM, Abdelbary AM, Al-Dessoukey AA, Moussa AS, Zayed AS, Mahmmoud O. The success of extracorporeal shock-wave lithotripsy based on the stone-attenuation value from non-contrast computed tomography. Arab J Urol. 2014; 12:155-161. http://dx.doi.org/10.1016/j.aju.2014.01.002.
8. Alrwaili A. A Non-Contrast Computed Tomography and Intravenous Urography Interrogation in Patients with Renal Colic at Hospitals. SM J Clin Med. 2018; 4(1): 1036.
9. Choi JW, Song PH, Kim HT. Predictive factors of the outcome of extracorporeal shockwave lithotripsy for ureteral stones. Korean J Urol 53, 424–430 (2012). http://dx.doi.org/10.4111/kju.2012.53.6.424.

10. Kroczak T, Scotland KB, Chew B, Pace KT. Shockwave lithotripsy: techniques for improving outcomes. World J Urol 2017; 35:1341-1346. http://dx.doi.org/10.1007/s00345-017-2056-y.

11. Assimos D, Krambeck A, Miller NL, Monga M, Murad MH, Nelson CP, et al. Surgical management of stones: American urological association/endourological society guideline, PART II. J Urol 2016; 196:1161e9. http://dx.doi.org/10.1016/j.juro.2016.05.090.

12. Berber-Deseusa A, Maldonado-Ávila M, Garduño-Arteaga ML, Jaspersen- Gastelum J, Virgen-Gutiérrez F, Rodríguez-Nava P. Predictive success factors in extracorporeal shock wave lithotripsy (ESWL). Rev Mex Urol 2017; 77 (4): 251-257.

13. Dede O, Şener NC, Baş O, Dede G, Bağbancı MŞ. Does morbid obesity influence the success and complication rates of extracorporeal shock wave lithotripsy for upper ureteral stones? Turk J Urol 2015; 41(1): 20-23. http://dx.doi.org/10.5152/tud.2015.94824.

14. Bulent K, Eyyup SP, Ismail Y, Suleyman S. Effects of the Distance between Renal Calculi and Skin and the Body Mass Index on the Success of ESWL among Renal Calculi Patients. JOJ uro & nephron. 2017; 3(3): 555614. http://dx.doi.org/10.19080/JOJUN.MS.ID.555614.

15. Pareek G, Armenakas NA, Panagopoulos G, Bruno JJ, Fracchia JA. Extracorporeal shock wave lithotripsy success based on body mass index and Hounsfield units. Urology 2005; 65:33–36. http://dx.doi.org/10.1016/j.urology.2004.08.004.

16. Pompeo A, Molina WR, Juliano C, Sehrt D, Kim FJ. Outcomes of intracorporeal lithotripsy of upper tract stones are not affected by BMI and skin-to-stone distance (SSD) in obese and morbid patients. Int Braz J Urol. 2013; 39:702–709. http://dx.doi.org/10.1590/S1677-5538.IBJU.2013.05.13.

17. Jacobs BL, Smaldone MC, Smaldone AM, Ricchiuti DJ, Averch TD. Effect of skin-to-stone distance on shockwave lithotripsy success. J Endourol2008;22(8):1623-1627. http://dx.doi.org/10.1089/end.2008.0169.

18. Al-Ansari A, As-Sadiq K, Al-Said S, Younis N, Jaleel OA, Shokeir AA. Prognostic factors of success of extracorporeal shock wave lithotripsy (ESWL) in the treatment of renal stones. Int Urol Nephrol 2006;38(1):63-67. http://dx.doi.org/10.1007/s11255-005-3155-z.

19. Joshi HN, Karmacharya RM, Shrestha R, Shrestha B, de Jong IJ, Shrestha RKM. Outcomes of extracorporeal shock wave lithotripsy in renal and ureteral calculi. Kathmandu Univ Med J 2014; 12 :51-54.

20. Shinde S, Al Balushi Y, Hossny M, Jose S, Al Busaidy S. Factors Affecting the Outcome of Extracorporeal Shockwave Lithotripsy in Urinary Stone Treatment. Oman Med J. 2018; 33(3): 209–217. http://dx.doi.org/10.5001/omj.2018.39.

21. Lee HY, Yang YH, Lee YL, Shen JT, Jang MY, Shih PM, et al. Noncontrast computed tomography factors that predict the renal stone outcome after shock wave lithotripsy. Clin Imaging 2015; 39(5):845-850. http://dx.doi.org/10.1016/j.clinimag.2015.04.010.